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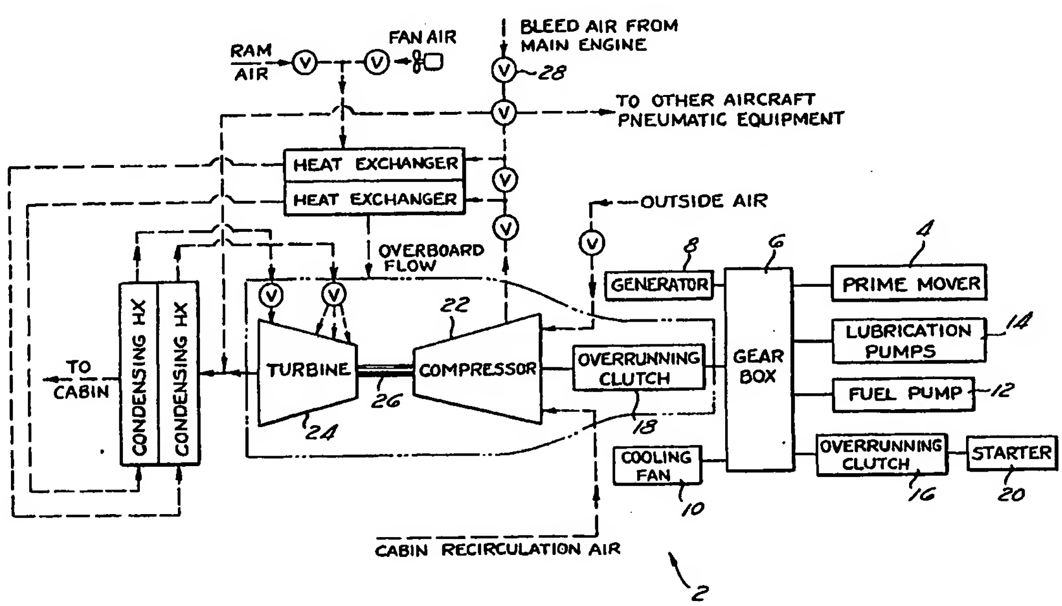
(54) **Integrated auxiliary power and environmental control unit**

(57) The unit comprises a prime mover 4 (auxiliary engine), a variable geometry compressor 22, and controlled emission turbine 24 which is shaft-coupled to the compressor and cooperating with the compressor to form an environmental control unit. In a first operating mode, the prime mover 4 drives the compressor through a gearbox 6 and overrunning clutch 18 and air from the compressor passes through heat exchanger circuits to the turbine and thence to the cabin of a vehicle. In a second mode, when the prime mover 4 is not running, a valve 28 is opened and bleed air from a propulsion engine of the vehicle and cabin recirculation air pass through respective heat exchanger circuits to the turbine and cabin. In a third operating mode, the prime mover drives the compressor and the compressed air therefrom is fed solely to the other aircraft pneumatic equipment, specifically the starters for the main engine.

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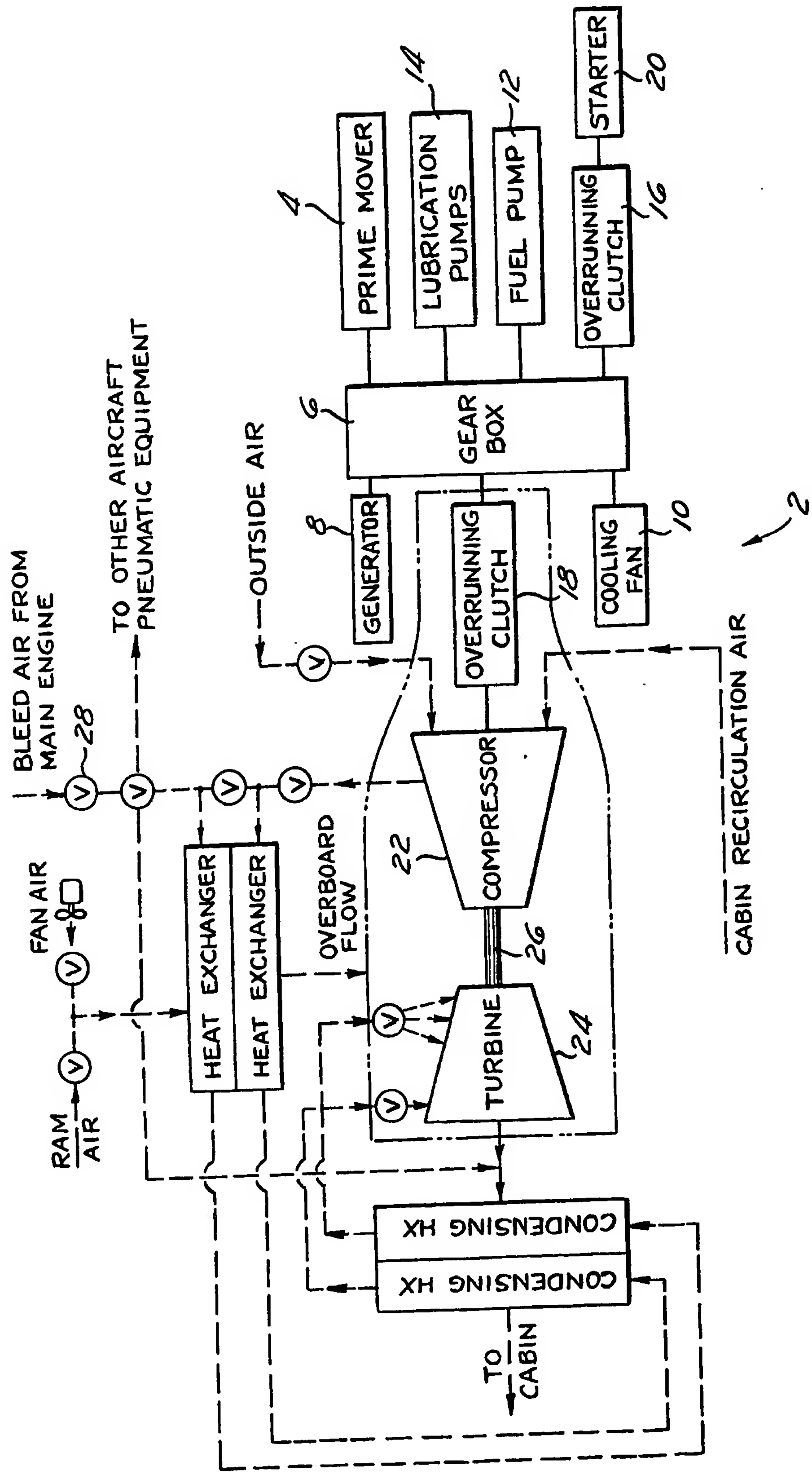

PRIME MOVER
4
LUBRICATION PUMPS
14
FUEL PUMP
12
STARTER
20
OVERRUNNING CLUTCH
16
GEAR BOX
6
GENERATOR
8
OVERRUNNING CLUTCH
18
COOLING FAN
10
2
OUTSIDE AIR
TO OTHER AIRCRAFT PNEUMATIC EQUIPMENT
BLEED AIR FROM MAIN ENGINE
28
COMPRESSOR
22
26
TURBINE
24
CABIN RECIRCULATION AIR
FAN AIR
RAM AIR
HEAT EXCHANGER
HEAT EXCHANGER
OVERBOARD FLOW
CONDENSING HX
CONDENSING HX
TO CABIN

SPECIFICATION

**Integrated auxiliary power and environmental control unit**

This invention relates to integrated auxiliary power and environmental control units for aircraft and other vehicles.

In large aircraft, it has been the custom to provide an auxiliary power unit, comprising a prime mover driving a compressor, which serves to provide compressed air for powering the recirculating air environmental control unit, or for powering the airplane engine air starters. In passenger planes, it has been customary to also provide an environmental control unit for cooling, heating and pressurization of the passenger compartment. This unit has comprised a turbine which may be driven either by bleed air from the airplane's propulsion engines or by compressed air provided by a separate prime mover (auxiliary power unit). The prime mover mechanically drives a compressor for providing additional air flow to the environmental control unit turbine, to provide both the proper aircraft ventilation rate and contribute a low energy absorption method for the environmental control cycle. Air flow from the environmental control unit turbin is also provided to the aircraft cabin at the desired temperature and pressure. It has been conventional, heretofore, to drive the compressor of the environmental control unit at maximum outputs to provide a maximum flow rate for the limiting heating or cooling condition and adjust the output flow temperature by flow mixing through a temperature control valve. In large passenger planes, it has been customary to provide a plurality of independent environmental control units.

It will be apparent that, where a plurality of independent environmental control units are provided, it is also necessary to provide a corresponding plurality of sensor and control system. It should also be noted that, with the systems of the prior art, it has been necessary to operate each of these environmental control unit compressors at maximum output at all times, regardless of the actual demand, in order to be able to accommodate a range of potential demands. Obviously, this is not energy efficient.

These disadvantages of the prior art are overcome with the present invention which is defined in claim 1. The invention enables the functions of an auxiliary power unit plus a plurality of environmental control units, of the prior art, to be accomplished with substantially improved energy efficiency, reduced complexity, lower operating and maintenance costs and lighter, less expensive equipment.

The preferred embodiment of the present invention comprises an auxiliary power unit comprising a prime mover and a variable geometry compressor shaft-coupled to a controlled emission turbine and which can be driven by bleed air from the plane's propulsion engines or can be connected through an overruning clutch to be driven by the auxiliary engine, the compressor and turbine forming an environmental control unit. When this unit is directly driven by the auxiliary engine, it can serve the needs of both the auxiliary power unit and the environmental control unit. Alternatively, when the plane is in flight, the compressor can be decoupled from the power unit by means of the overruning clutch, and can be driven by bleed air from the plane's propulsion engines to serve the environmental control unit.

It will be seen that a single compressor employed in the present invention replaces two compressors in prior art equipment. This provides substantial reductions in weight and size, which can be translated into greater financial return or reduced requirements for a given payload. In addition, the variable geometry compressor has variable exit vanes which can be adjusted to regulate flow to the turbine to substantially constant pressure, and thereby maintain near peak operating efficiencies. The turbine emission can be controlled by partitioning the flow supply to achieve flow matching with the compressor, to minimize pressure throttling to the turbine and, hence, to maintain near constant pressure over a wide flow operating range. This also permits a portion of the compressor discharge air to be diverted from the turbine for other purposes, such as driving an engine starter motor. In addition, this arrangement enables the environmental control unit to operate at constant speed, near peak design efficiency, throughout most of the operating range. Consequently, the unit of the present invention is highly energy efficient. The unit can also be compact, light-weight and economical to install and maintain. Moreover, the unit can operate at constant speed, near peak design efficiency, over a wide operating range.

The invention will be described in more detail by way of example, with reference to the accompanying drawing, in which the figure is a diagrammatic representation of an integrated auxiliary power and environmental control unit embodying the present invention.

The figure shows an integrated auxiliary power unit and environmental control unit having an auxiliary engine indicated as a prime mover 4 which drives a gearbox 6 and through the gearbox 6, drives a variety of equipment, such as generator 8, cooling fan 10, fuel pump 12, lubrication pump 14 and overrunning clutch 18. Another overrunning clutch 16 is engageable for the starter 20 to rotate the prime mover 4 through the gearbox 6, for starting the prime mover. The clutch 18 is engageable to drive a variable geometry compressor 22 and a controlled emission turbine 24 which are mounted on a common drive shaft 26.

The variable geometry compressor 22 is formed with variable exit diffuser vanes which are adjustable to control the flow area and pressure of air passing into or out of the compressor 22. This permits operation of the compressor 22 at nearly constant pressure and near peak efficiency with low energy utilization, with the prime mover 4 providing minimal drive power or, if the prime mover 4 is inactive, the compressor 22 is driven by a minimal amount of engine bleed air (engine power loss), by opening a valve. If desired, a variable set of com-

pressor inlet guide vanes can also be added to further reduce the energy utilization of the environmental control unit. Such compressors are components of the Lycoming T55-L11 aircraft engine, manufactured by AVCO Lycoming Corporation, Stratford, Connecticut, and as components of engines developed by the National Aeronautics and Space Administration. The controlled emission turbine 24 uses controllable inlet ducting to partition the amount of air flow input to the turbine, while maintaining substantially constant pressure so as to assure operation of the turbine 24 at near peak efficiency. This permits adjustment of the emission from the turbine 24 to match the flow from compressor 22 which minimizes pressure throttling to the turbine and permits maintenance of near constant pressure over a wide flow operating range.

The illustrated valves allow various operating modes to be established. In a first mode the primer mover 4 is running to drive the compressor/turbine for cabin pressurization, cabin recirculation air and outside air being drawn into the compressor and passed vai the heat exchanges and turbine to the cabin. In a second mode, when the prime mover is not running, the valve 28 is opened and main engine bleed air and cabin recirculation air are passed through the respective heat exchanger circuits and to the cabin. In a third mode, the prime mover 4 drives the compressor which simply comprises outside air for feeding to other aircraft pneumatic equipment, specifically the main engine starters. The inlet valves to the turbine are closed to prevent air then being taken off via the heat exchanger circuits.

The integrated unit described combines the energy saving features of an energy-efficient, recirculating, environmental control unit and a load-compressor, auxiliary power unit into a single integrated unit, which can be controlled to expend less energy than a separate environmental control unit and a separate auxiliary power unit, throughout the aircraft mission. Obviously, combining the environmental control unit and auxiliary power unit permits elimination of one compressor, with attendant savings in weight, space, installation and operating costs. Furthermore, shaft coupling of the compressor and turbine is about 98% efficient, while conventional air coupling is only about 80% efficient.

CLAIMS

1. An integrated environmental control and auxiliary power unit for a vehicle having a propulsion engine, the unit comprising an auxiliary engine coupled to a compressor through an overrunning clutch, a turbine, a common drive shaft coupling the compressor and turbine for simultaneous rotation and, means for supplying bleed air from the propulsion engine to drive the coupled compressor and turbine when the auxiliary engine is not running, and means for independently utilizing the output flows from the compressor and the turbine.

2. A unit according to claim 1, wherein the utilizing means include means for feeding air from the compressor to a penumatic starter for the propulsion engine.

3. A unit according to claim 1 or 2, wherein the utilizing means include means for feeding air from the turbine to a cabin of the vehicle.

4. A unit according to claim 1, 2 or 3, wherein the utilizing means include means for feeding air from the compressor through at least one heat exchanger circuit to the turbine.

5. A unit according to any of claims 1 to 4, wherein the means for supplying bleed air comprise a heat exchanger circuit for supplying the bleed air to the turbine.

6. A unit according to any of claims 1 to 5, wherein the compressor is a variable geometry compressor.

7. A unit according to claim 6, wherein the turbine is a controlled emission turbine.

8. An integrated environmental control and auxiliary power unit for a vehicle having a propulsion engine substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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